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Microbial Petinolytic Enzymes

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Abstract

Apart from plant, microorganisms such as bacteria and fungi are currently well known to be able to hydrolyze pectic substances like pectin, protopectin and pectic acids, thanks to a various forms of pectinolytic enzymes. These enzymes have been intensively used in various fields. The present review is focused mainly on microbial pectinolytic enzymes.

Keywords: pectic substances, pectinases, bacteria, fungi, yeast.

1. Introduction

Pectic substances and celluloses are the most abundant carbohydrates present in plants (Table 1). Pectic substances, present in cell wall and middle lamella, contribute firmness and structure to plant tissues [1]. According to the American Chemical Society pectic substances are classified into four main types [2]: (I) Protopectin, (II) Pectic acid, (III) Pectinic acids, (IV) Pectin (Polymethyl galacturonate). Pectinases or pectinolytic enzymes, a heterogeneous group of related enzymes, are responsible for hydrolyze of pectic substances present in plant tissues. Pectinases are one of the most widely distributed enzymes in microorganisms (bacteria and fungi) and higher plants [3]. Indeed, It has been shown in the literature that pectinases account for 25% of the global food enzymes sales.

Almost all the commercial preparations of pectinases are produced from fungal sources [4]. Aspergillus niger is the most commonly used fungal species for industrial production of pectinolytic enzymes [5, 6].

Pectinolytic enzymes are of significant importance in the current biotechnological era with their all embracing applications in fruit juice extraction and its clarification, scouring of cotton, degumming of plant fibers, waste water treatment, vegetable oil extraction, tea and coffee fermentations, bleaching of paper, in poultry feed additives and in the alcoholic beverages and food industries [7]. Protopectinases, polygalacturonases, lyases and pectin esterases are among the extensively studied pectinolytic enzymes.

2. Occurrence of pectinases

2.1. Protopectinases

These enzymes catalyze the solubilization of protopectin. They are found in the culture filtrates of yeast and yeast-like fungi. They have been isolated from *Kluyveromyces fragilis* IFO 0288, *Galactomyces reesei* L., *Trichosporon penicillatum* SNO 3 [3] and from the culture filtrate of a wide range of *Bacillus* sp. [8]. Protopectinases have also been found in *Trametes* sp. [9].

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Table 1. Percentages of pectic substances in fruits and vegetables [7]

Fruit/vegetable	tissue	Pectic substance (%)
Apple	Fresh	0.5–1.6
Banana	Fresh	0.7–1.2
Peaches	Fresh	0.1–0.9
Strawberries	Fresh	0.6–0.7
Cherries	Fresh	0.2–0.5
Peas	Fresh	0.9–1.4
Carrots	Dry matter	6.9–18.6
Orange pulp	Dry matter	12.4–28.0
Potatoes	Dry matter	1.8–3.3
Tomatoes	Dry matter	2.4–4.6
Sugar beet pulp	Dry matter	10.0–30.0

2.2. Polygalacturonases

Polygalacturonases hydrolyze the polygalacturonic acid chain by addition of water and are the most abundant among all the pectinolytic enzymes. Endo-polygalacturonases are widely distributed among fungi, bacteria and many yeasts [10]. They have been reported in many microorganisms, including *Aureobasidium pullulans* [11], *Rhizoctonia solani* Kuhn [12], *Fusarium moniliforme* [13], *Neurospora crassa* [14], *Rhizopus stolonifer* [15], *Aspergillus* sp. [16], *Thermomyces lanuginosus* [17], *Peacilomyces clavisporus* [18]. Endo-polygalacturonases are also found in higher plants and some plant parasitic nematodes [9].

Exo-polygalacturonases have been reported in *Erwinia carotovora* [19], *Agrobacterium tumefaciens* [20], *Bacteroides thetaiotamicron* [21], *Erwinia chrysanthemi* [22], *Alternaria mali* [23], *Fusarium oxysporum* [24], *Ralstonia solanacearum* [25], *Bacillus* sp. [22].

2.3. Lyases

Lyases catalyze the trans-eliminative cleavage of the galacturonic acid polymer. Polygalacturonate lyases (or pectate lyases) are produced by many bacteria and some pathogenic fungi. Lyases have been isolated from bacteria and fungi associated with food spoilage and soft rot. They have been reported in *Colletotrichum lindemuthionum* [26], *Bacteroides thetaiotaomicron* [27], *Erwinia carotovora* [28], *Amucala* sp. [29], *Pseudomonas syringae pv. glycinea* [30], *Colletotrichum magna* [31], *Erwinia chrysanthemi* [32, 33], *Bacillus* sp. [34, 35], *Bacillus* sp. DT-7 [36], *Colletotrichum gloeosporioides* [37, 38]. They have been reported to be produced by *Aspergillus japonicus* [39], *Penicillium paxilli* [40, 41], *Penicillium* sp. [42,43,44], *Pythium splendens* [45] *Pichia pinus* [46], *Aspergillus* sp. [47], *Thermoascus auratniacus* [48].

2.4. Pectinesterases

This enzyme liberates pectins and methanol by de-esterifying the methyl ester linkages of the pectin backbone. Pectinesterase are found in plants, plant pathogenic bacteria and fungi [49]. It has been reported in *Rhodotorula* sp. [50], *Phytophthora infestans* [51], *Erwinia chrysanthemi* B341 [52], *Saccharomyces* cerevisiae [53], *Lachnospira pectinoschiza* [54], *Pseudomonas solanacearum* [55], *Aspergillus niger* [56,57], *Lactobacillus lactis* subsp. *Cremoris* [58], *Penicillium frequentans* [59], *Erwinia chrysanthemi* 3604 [60], *Penicillium occitanis* [61], *Aspergillus japonicus* [62] and others. There are many reports of occurrence of pectinesterase in plants.

3. Conclusion

The probable reason for the existence of a great diversity of pectinolytic organisms is that the pectic substances could be present in various forms in the nature. To date, certain species of bacteria, molds, and yeast are commonly studied for their aptitude to produce pectinases among others. However, *Aspergillus niger* remains, currently the most used fungal specie for industrial production of pectinolytic

enzymes. Therefore, the discovery of other microorganisms having a stable ability to produce such enzymes would constitute an enormous progress in biotechnology.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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